Anti-theft Protection of Vehicle by GSM & GPS with Fingerprint Verification

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Abstract—**Recently vehicle tracking system is getting vast popularity because of the rising number of the stolen vehicles. Vehicle theft is happening on parking and sometimes driving in unsecured places. This research work explores how to avoid this kind of stealing and provides more security to the vehicles. The implemented system contains single-board embedded system which is equipped with global system for mobile (GSM) and global positioning system (GPS) along with a microcontroller installed in the vehicle. The use of GSM and GPS technologies allows the system to track the object and provides the most up-to-date information about on-going trips. Moreover, fingerprint verification is done in the implemented system to ensure the driving of correct person. The implemented system is very simple with greater security for vehicle anti-theft protection and low cost technique compared to others.**

Keywords—GMS; GPS; fingerprint; embedded system; vehicle anti-theft protection.

I. INTRODUCTION

A vehicle tracking system combines the installation of an electronic device in a vehicle or fleet of vehicle to enable the owner or third party to track the vehicle's location and collecting data in the process. Modern Vehicle Tracking system (VTS) is the technology used to determine the location of a vehicle using different methods like GSM and GPS module and other radio navigation systems operating through satellites and ground based stations [1, 2]. GSM and GPS based vehicle location and tracking system provides effective, real time mapping based vehicle location tracking. The system uses geographic position and time information from the Global Positioning Satellites [3].

After emerging of GPS system developed by The United States government [4], first it was only for military purpose. After opening for public, it has been used widely. Al-Bayari and Sadoun discussed in details Automatic Vehicle Location (AVL) system that works under GIS environment [5]. A complete FPGA implementation of the vehicle position tracking system using short message services (SMS) was reported by Hapsari [6]. The design and implementation of a mobile object management system that makes use of the existing GSM networks and its extension GPRS for data communication was discussed by Xiaobo Fan et al. [7]. Hsiao and Chang developed analytical model to analyze the optimal location update strategy with the objective of minimum total cost [8]. Tamil et al. did similar works [9]. Video surveillance and tracking of moving civilian vehicle done by Nishi Kanta Pati added new dimension to the development of the tracking systems [10].

In this research work, a system has been developed based on microcontroller that consists of a GPS and GSM. A two way communication process is achieved using a GSM modem. This study also comprises of a bio-metric protection system of the vehicle and fingerprint verification of the driver of the vehicle is used to protect the vehicle from anti-theft. Fingerprint recognition or fingerprint authentication can be defined as a method of verifying a match between two human fingerprints in an automated behaviour. Fingerprints are one of many forms of biometrics used to identify individuals and verify their identity. It is known that every person has a unique fingerprint image [11]. When driver gives his verified fingerprint image before starting the vehicle, the system will be considered as fair condition. But when vehicle's location is changed without fingerprint verification, the system will be taken as abnormal condition. Then the system will send an SMS to owner of the vehicle with an URL of 'GOOGLE MAP' [12] having the co-ordinate of the current location of the vehicle. SMS will be then sent to the owner having updated location's co-ordinate every interval of 10 seconds until doing the proper fingerprint verification. Moreover, vehicle's owner can get the vehicle's location at any time by SMS after making a 'missed call'.

II. METHODOLOGY

As shown in fig. 1, GPS receiver receives messages from satellites and that is used to determine the satellite positions and time sent. The *x, y,* and *z* co-ordinate components of satellite position and the time sent are designated as $[x_i, y_i, z_i, s_i]$. Subscript *i* denotes the satellite and have the value 1, 2...*n*, where $n \geqslant 4$.Time of message reception indicated by the on-board receiver clock is $\tilde{t}_i$, the true reception time is$t_i = \tilde{t}_i - b$, where b is the receiver's clock bias from the much more accurate GPS system clocks employed by the satellites. All received satellite signals are biased at the same receiver clock (assuming the satellite clocks are all perfectly synchronized).

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The message's transit time is $\tilde{t}_i - b - s_i$, where s_i is the satellite time. As the messages go at the speed of light c, the distance is $(\tilde{t}_i - b - s_i)c$. For n satellites, the equations to satisfy are:

$$(x - x_i)^2 + (y - y_i)^2 + (z - z_i)^2 = ([\tilde{t}_i - b - s_i]c)(1)$$

$$i = 1,2,,\ldots.,n$$

or in terms of pseudo ranges, $p_i = (\tilde{t}_i - s_i)c$ as

$$\sqrt{(x - x_i)^2 + (y - y_i)^2 + (z - z_i)^2} + bc = p_i[13](2)$$

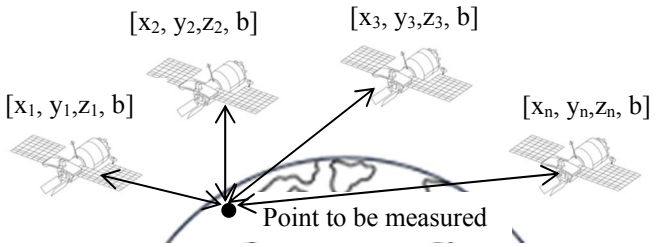


Fig. 1 GPS system with satellites.

Signals from at least four satellites are necessary to attempt solving these equations. GPS receiver position's three component and the clock bias, these four unknowns *[x, y, z, b]* are to be found. These can be solved by algebraic or numerical methods. Existence and uniqueness of GPS solutions are discussed by Abell and Chaffee [14]. When *n* is greater than 4, this system is over determined and a fitting method must be used.

A fingerprint sensor is also used for bio-metric verification. There are many fingerprint sensor technologies i.e. optical, capacitive, thermal, RF, ultrasonic, piezo-electric, piezo-resistive, MEMS. Optical sensor technology has been used here. Captured finger image is digitally processed and stored in memory as a template. The fingerprint of Vehicle's driver is taken by this device before the starting of vehicle. Fingerprint matching algorithm is used to compare with previously enrolled image for checking authentication. Among correlation-based matching, ridge feature-based matching and minutiae-based matching, last one is popular as it is efficient and accurate. If vehicle's location is changed without fingerprint verification, the system will consider that something is going wrong. Then the GPS engine will collect the co-ordinate of that place and send SMS to the cell phone number of the owner of the vehicle.

As the data getting from GPS has some error [4] due to delay in ionosphere, cloudy sky, multi path fading occurred by tall trees, buildings or mountains, system can detect it as abnormal situation if gained co-ordinate has slightly changed due to its error. Horizontal accuracy is normally 2-15 meters in open sky. It is more than 50 meters inside a building (i.e. garage etc.). So we have created an imaginary geo-fence of radius of 100meters. When the location of that vehicle will be found out of that geo-fence without proper fingerprint verification then the system will take necessary steps. Fig. 2 shows the methodology of sending SMS with proper security check. From Fig. 2, it is seen that if a parked vehicle moves from the geo-fence with proper fingerprint verification, then no SMS will be sent. But if a parked vehicle moves from the geo-fence created without proper fingerprint verification, then there will be an SMS sent to the owner's cell phone with a 'GOOGLE MAP' link containing appropriate co-ordinate of that location. In case to park a vehicle, one has to reset the system. Then the system creates new geo-fence centring that new place.

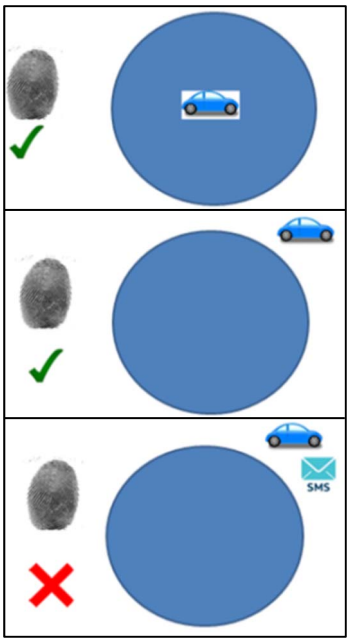


Fig. 2 Security check and sending SMS.

After initialization of GPS receiver, it gets co-ordinate (latitude, longitude and altitude), time and several others information in NMEA format [15]. This information is being updated in every second. After starting, microcontroller gets 1st co-ordinate from GPS receiver. Following updated co-ordinate, it checks whether the distance of the updated location of updated co-ordinate is greater than 100 m or not. If lon_i and lon_f are the initial and final longitude and lat_i and lat_f are the initial and final latitude, then from Haversine formula [16] we can get distance, D.

$$dlon = lon_f - lon_i \ (3)$$

$$dlat = lat_f - lat_i \quad (4)$$

$$a = (\sin\left(\frac{dlat}{2}\right))^2 + \cos(lat_i) * \cos(lat_f) * (\sin\left(\frac{dlon}{2}\right))^2 (5)$$

$$c = 2 * \text{atan2}\left(\sqrt{a}, \sqrt{(1-a)}\right) \quad (6)$$

$$D = R * c \quad (7)$$

Here, R is the radius of the earth. There are still have some error because this formula does not take into account the non-

spheroidal (ellipsoidal) shape of the earth. It tends to beunderestimated trans-equatorial distances and overestimated trans-polar distances. For simplicity, earth's average radius 6380 km could be used.

Owner of the vehicle can also get the location of the vehicle anytime by giving a 'missed call'. Flow chart of the whole procedure is depicted in Fig. 3.

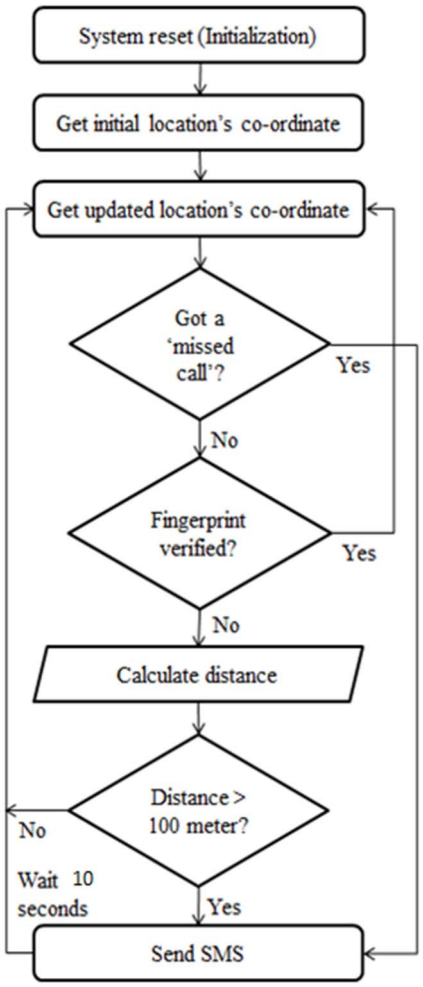


Fig. 3 Flow chart of security check and sending SMS.

III. System Design

In this research work, Arduino Mega2560 microcontroller is used for interfacing to various hardware peripherals. An Arduino mega2560 microcontroller is interfaced to a GSM modem and GPS receiver. A GSM modem is used to send the position of the vehicle from a remote place. SIM908 [17] is used in this study. Both GSM and GPS engines are included in one device. GT-511C1R [18] is used as fingerprint device.

Fig. 4 shows the block diagram of vehicle tracking system with Fingerprint verification. Both GSM and GPS engines have separate antenna. GSM, GPS and fingerprint devices are connected via microcontroller.

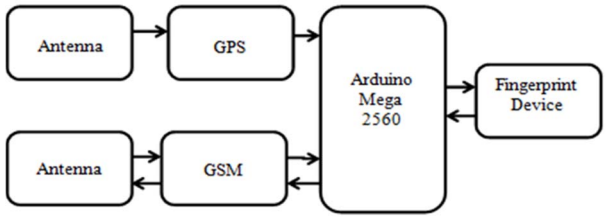


Fig.4 Block diagram of vehicle tracking system with fingerprint verification.

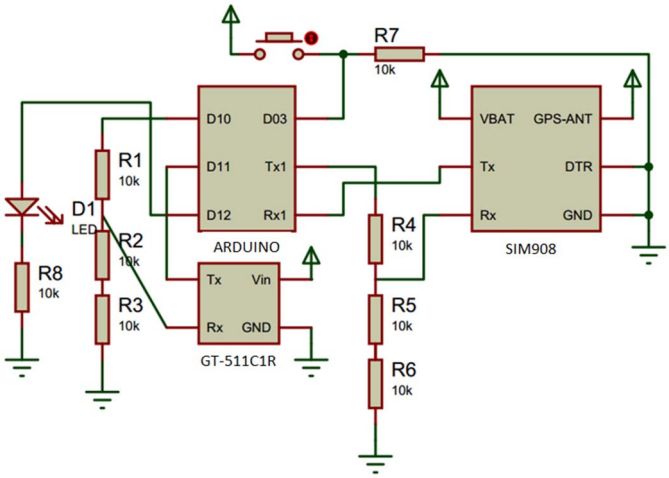


Fig. 5 Schematic diagram of in-vehicle tracking unit.

IV. System Description

In the vehicle, tracking unit is installed which includes Arduino-2560, SIM908 and GT-511C1R. SIM908 and GT-511C1R device are connected to the Arduino via serial COM port. Proper voltage level conversion is done by resistor divider. Fig. 5 shows the schematic diagram of in-vehicle tracking unit. Various parts of the tacking unit are described below.

A. Arduino MEGA-2560 Microcontroller

Arduino MEGA-2560 [19] is powerful microcontroller board based on ATmega2560. It has 54 digital input/output pins (of which 14 can be used as PWM outputs), 16 analogue inputs, 4 UARTs (hardware serial ports. It has 256 KB of flash memory, 8 KB of SRAM and 4 KB of EEPROM. Fig. 6 shows the Arduino MEGA Board.

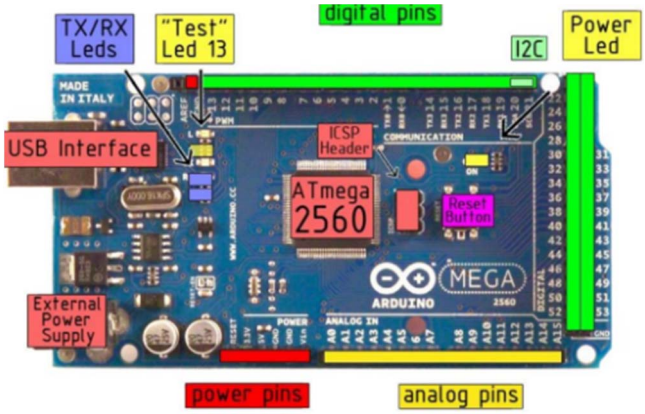


Fig. 6 Full specification of Arduino MEGA 2560.

B. GPS/GPRS/GSM (SIM908)

SIM908 has Quad-band GPRS/GSM engine. It works on the frequencies of 900 MHz, 1800 MHz, 850 MHz and 1900 MHz [20]. GPS technology for satellite navigation is also supported in this device. As both of the GPS and GSM technology is supported by it, any on purpose tracking is possible at anywhere and anytime with signal coverage.

Fig.7 SIM908 module.

C. GSM and GPS Antenna

In this project, GSM antenna used is passive type and GPS antenna is active type. Voltage range of GPS antenna is 3-5 volt.

Fig. 8 GSM (left) and GPS (right) antenna.

D. Fingerprint Module (GT-511C1R)

GT-511C1R has an on-board optical sensor and 32-bit CPU that does reading and identifying the fingerprints with sending the corresponding command. The module can only store up to 20 different fingerprints and is only capable of 30° fingerprint recognition. The optical fingerprint algorithm uses 240x216 pixel image for its input. It captures raw image from the sensor and converts it to 240x216images for the fingerprint algorithm. Not pressing of finger returns with non-acknowledge. Fig. 9 shows the fingerprint scanner (GT-511C1R).

Fig. 9 Fingerprint module (GT-511C1R).

V. System Implementation& Result

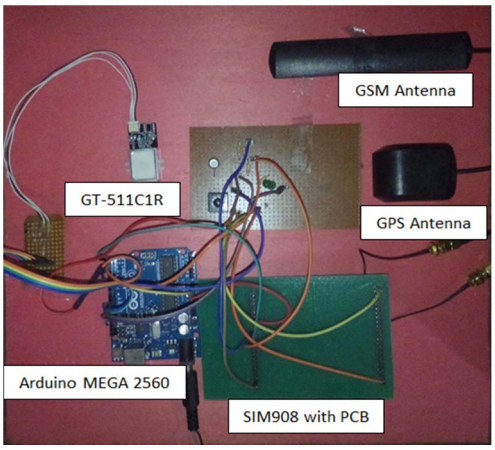
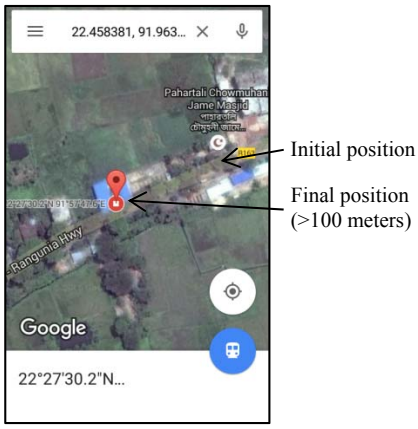
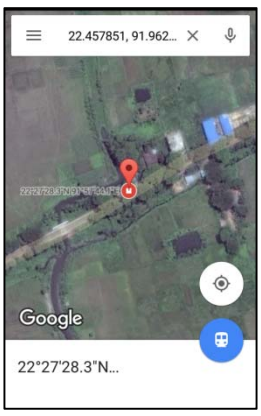


Fig. 10 System implementation.

After doing hardware and software related works, the entire system was tested in a vehicle to ensure that the vehicle tracking system is working well and meets the requirement. When the vehicle moves out of the imaginary geo-fence without proper fingerprint verification, then an SMS is sent to the owner's cell phone with link including vehicle's co-ordinate. After that, an SMS is sent automatically after every 10 seconds including updated location's co-ordinate. Then proper fingerprint is given and sending massages has been stopped.

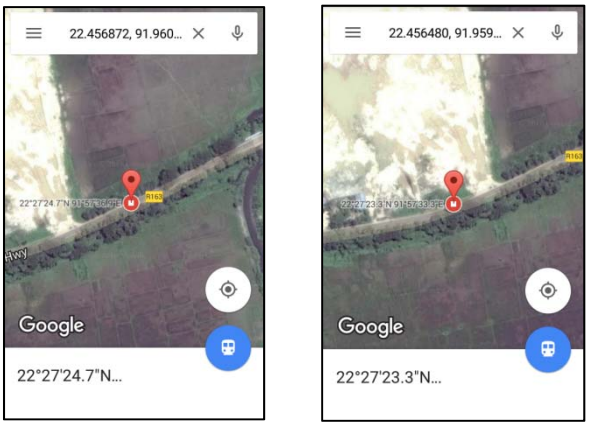


(a)



(b)

(c)



(d) (e)

Fig. 11 Location on map (a) initial position and final posiion (> 100 meters), (b)-(e) subsequent positions of 10 seconds interval (from immediate previous positions).

TABLE I. LOCATIONS' CO-ORDINATE ANALYSIS

No. of positions	Location's co-ordinate (latitude, longitude)	Distance from previous locations (meters)
1	22.458768N, 91.964138E	-
2	22.458381N, 91.963226E	102.21
3	22.457851N, 91.962248E	115.86
4	22.457358N, 91.961286E	112.36
5	22.456872N, 91.960261E	117.12
6	22.456480N, 91.959260E	110.86

After doing click on that link, location on the map is showed. Fig. 11 shows the position on the map. In Fig. 11, first screenshot is the location of the vehicle pointed on that place exceeding the distance of 100 m. Subsequent screenshots are the location of moving vehicle after every 10 seconds of first massage. Distance is calculated by using Haversine formula.

VI. COST ANALYSIS

The different essential components with respective quantities and cost are given to implement the system in Table II. The wiring, PCB & miscellaneous cost are considered approximately.

TABLE II. COST ANALYSIS

No.	Equipment	No. of set(s)	Price (USD)
1.	ARDUINO MEGA-2560	1	12.67
2.	SIM908	1	25.35
3.	GT-511C1R	1	38.02
4.	Antennas	2	5.07
5.	Wire & Miscellaneous	-	1.27
Total cost			**82.38**

VII. CONCLUSIONS

In this research work, vehicle location can be tracked and prevention of it from theft with fingerprint verification is done with minimum cost in quasi real-time mode. Fingerprint technology is very effective security check technology and also in lower cost to avoid stealing of vehicles. In future, smart-phone (i.e. android, windows) application can be made and interfacing a dedicated smart-phone installed in vehicle with fingerprint device can be done to get real-time vehicle tracking with inter-active mapping.

ACKNOWLEDGMENT

The authors would like to thank the Department of Electrical and Electronic Engineering of Chittagong University of Engineering and Technology (CUET), Chittagong-4349, Bangladesh.

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